

## **TABLES**

**Table 1-1**  
**Potential Ice Scour Events Identified in the Hydrologic Record**  
**for the Clark Fork River above Missoula (USGS Station #12340500)**  
**Milltown Reservoir Focused Feasibility Study**

Rank	Date	Peak Flows (cfs)
1	February 3, 1996	12,900
2	February 25, 1986	8,340
3	January 17, 1974	8,010
4	February 26, 1956	7,480
5	February 1, 1971	7,330
6	January 6, 1984	7,000
7	December 24, 1964	6,620
8	December 4, 1975	6,380
9	February 6, 1963	6,300
10	March 25, 1960	5,940
11	February 22, 1982	5,630
12	December 24, 1955	5,310
13	February 12, 1951	4,990
14	February 23, 1968	4,650

**Notes:**

1. Not all potential events identified in this table based on peak water flows represent true ice jam events. The US Army Cold Regions Research and Engineering Laboratory (CRREL) ice jam database identified only four reported ice jams on the Clark Fork or Blackfoot Rivers in Missoula County (CRREL, 1997). Anecdotal information suggests that ice jam events at Milltown have occurred on an approximately 10-year return frequency during recent decades.

Source: Technical Report, "Analysis of Meteorological and Hydrological Conditions Contributing to Ice Formation and Breakup on the Clark Fork River in January and February 1996", prepared by ENSR Consulting and Engineering for ARCO, March 1998.

**Table 1-2**  
**Summary Statistics for USGS Surface Water Quality Data**  
**from Sampling Stations Near Milltown Reservoir**  
**Milltown Reservoir Combined Feasibility Study**

	Total Metals (µg/L)					Dissolved Metals (µg/L)				
	Arsenic	Cadmium	Copper	Lead	Zinc	Arsenic	Cadmium	Copper	Lead	Zinc
<b>Clark Fork River at Turah Bridge (USGS gaging station 12334550)</b>										
<b>1985 - 1992</b>										
Sample Number	42	42	41	42	42	42	42	42	42	42
Mean	13.1	0.9	67.1	16.2	126.5	6.3	0.5	6.2	1.7	10.3
Median	8	0.5	30	8.5	50	5	0.5	5	1	8
Minimum	5	0.5	3	0.5	5	4	0.5	2	0.5	1.5
Maximum	110	4	500	100	1100	17	1	25	7	39
Lower Quartile	7	0.5	14	3.25	32.5	5	0.5	3	0.5	5
Upper Quartile	11	1	56	18.25	87.5	7	0.5	7	2.5	12.75
Std.Dev.	18.4	0.8	118.7	22.9	254.4	2.6	0.1	5.0	1.5	8.2
<b>1993 - 1997</b>										
Sample Number	42	42	42	39	42	42	42	42	39	42
Mean	11.0	0.5	36.8	6.4	55.7	6.7	0.1	6.0	0.3	6.7
Median	9	0.5	22.5	5	40	6	0.05	5	0.25	6
Minimum	5	0.5	3	0.5	5	4	0.05	2	0.25	1.5
Maximum	33	1	180	33	270	13	0.1	19	0.9	22
Lower Quartile	7	0.5	12	2	20	5	0.05	3	0.25	4.25
Upper Quartile	14	0.5	48.25	8.5	70	7	0.05	7	0.25	8
Std.Dev.	5.9	0.1	39.8	7.0	52.3	2.2	0.0	3.9	0.1	4.1
<b>Blackfoot River near Bonner (USGS gaging station 12340000)</b>										
<b>1985 - 1992</b>										
Sample Number	34	34	33	34	34	34	34	34	34	34
Mean	1.2	0.7	10.3	7.1	14.9	0.8	0.5	2.5	1.9	5.0
Median	1	0.5	8	5	10	0.5	0.5	2	1.25	3
Minimum	0.5	0.5	0.5	0.5	5	0.5	0.5	0.5	0.5	1.5
Maximum	3	2	34	20	60	2	1	6	8	15
Lower Quartile	1	0.5	6	2	5	0.5	0.5	1	0.5	1.5
Upper Quartile	1	0.5	12	13.25	20	1	0.5	3	2.5	7
Std.Dev.	0.6	0.4	7.5	6.1	13.7	0.4	0.1	1.5	1.9	4.0
<b>1993 - 1997</b>										
Sample Number	25	25	25	23	25	25	25	25	23	25
Mean	1.4	0.5	6.0	2.2	7.2	0.8	0.1	1.4	0.3	2.1
Median	1	0.5	3	0.5	5	1	0.05	0.5	0.25	1.5
Minimum	0.5	0.5	0.5	0.5	5	0.5	0.05	0.5	0.25	1.5
Maximum	4	0.5	34	25	40	2	0.1	7	2	6
Lower Quartile	0.5	0.5	1	0.5	5	0.5	0.05	0.5	0.25	1.5
Upper Quartile	2	0.5	8	2	5	1	0.05	2	0.25	1.5
Std.Dev.	1.0	0.0	8.7	5.0	7.5	0.4	0.0	1.6	0.4	1.3

**Table 1-2 (continued)**  
**Summary Statistics for USGS Surface Water Quality Data**  
**from Sampling Stations Near Milltown Reservoir**  
**Milltown Reservoir Combined Feasibility Study**

	Total Metals (µg/L)					Dissolved Metals (µg/L)				
	Arsenic	Cadmium	Copper	Lead	Zinc	Arsenic	Cadmium	Copper	Lead	Zinc
<b>Clark Fork River above Missoula (USGS gaging station 12340500)</b>										
<b>1989 - 1992</b>										
Sample Number	20	20	19	20	20	20	20	20	20	20
Mean	3.6	0.5	9.7	3.1	17.5	2.7	0.5	2.5	0.6	5.5
Median	3.5	0.5	8	2	10	3	0.5	2	0.5	4
Minimum	2	0.5	2	0.5	5	1	0.5	1	0.5	1.5
Maximum	6	0.5	31	11	60	4	0.5	6	1	16
Lower Quartile	2.75	0.5	4.5	1	10	2	0.5	2	0.5	1.5
Upper Quartile	4	0.5	10.5	3.5	22.5	3	0.5	3	0.625	8
Std.Dev.	1.4	0.0	7.7	3.1	14.3	0.8	0.0	1.2	0.2	4.3
<b>1993 - 1997</b>										
Sample Number	42	42	42	38	42	42	42	42	38	42
Mean	7.3	0.6	26.3	5.1	54.9	3.8	0.1	3.6	0.3	4.4
Median	5	0.5	10.5	2	20	3	0.05	3	0.25	3.5
Minimum	3	0.5	4	0.5	5	2	0.05	2	0.25	1.5
Maximum	69	5	400	78	1100	9	0.1	11	1.2	15
Lower Quartile	4	0.5	7	1	10	3	0.05	2	0.25	1.5
Upper Quartile	7	0.5	21.5	4	37.5	4	0.05	4	0.25	6.75
Std.Dev.	10.2	0.7	61.9	12.7	167.7	1.6	0.0	2.3	0.2	3.4

**Notes:**

Values reported as below detection were used at half the detection limit for statistical analysis.

Data from U.S. Geological Survey for the period 1985 through 1997 for Clark Fork River at Turah and the Blackfoot River near Bonner.

Data from U.S. Geological Survey for the period 1989 through 1997 for Clark Fork River above Missoula.

**Table 1-3**  
**MPC Data on Milltown Dam Operation Turbidity Impacts**  
**Milltown Reservoir Focused Feasibility Study**

<b>Year</b>	<b>Flow (cfs)</b>	<b>Background Turbidity (NTU)</b>	<b>Below Milltown (NTU)</b>	<b>Drawdown</b>
1980 July	5,570	1.4-16.5	28-240	8 ft/14 hours
1981 June-July	2,800-3,200	1.5-14.5	3.2-10	4 ft/4 days
1982 July	3,010-6,580	3-15	9.7-25	4.6 ft/10 days
1983 June	3,120-5,710	3.4-10	6.5-44	4.1 ft/8 days
1983 November	1,580-2,470	4.1-7.5	5-17.5	5.7 ft/~14 days
1983 December - January	1,800-2,470	2.9-88	5-71 <sup>(1)</sup>	Icing during low pool level. Missing samples below dam.
1984 July	2,160-4,170	3-8	4.5-22	4.5 ft/10 days
1985 June	2,310-3,460	2.5-5	5.5-24	6.1 ft/9 days

1. High value at "Van Buren St. Bridge." Sample missing for station below dam.

cfs = cubic feet per second

NTU = Nephelometric Turbidity Unit

Source: "Milltown Surface Water Quality, Total Recoverable Metals, Suspended Sediment Discharge Analysis" prepared by Land & Water Consulting, Inc. for ARCO, October 1999.

**Table 1-4**  
**Surface Water Quality During Spring 1997 Flood Event for Clark Fork and Blackfoot Rivers**  
**Milltown Reservoir Focused Feasibility Study**

Location	Date	Discharge (cfs)	Total Recoverable (ppb)					Dissolved (ppb)					TSS (ppm)
			Arsenic	Cadmium	Copper	Lead	Zinc	Arsenic	Cadmium	Copper	Lead	Zinc	
CFR at Turah	5/7/97	3840	12	<1	37	7	60	6	<0.10	5.3	<0.50	4.6	99
	5/13/97	6660	19	<1	93	16	150	7	<0.10	13	<0.50	4.8	442
	5/14/97	6420	18	<1	73	14	130	7	<0.10	9.6	<0.50	7.5	332
	5/15/97	7500	20	<1	92	18	180	7	<0.10	12	<0.50	7.8	348
	5/16/97	8480	22	<1	99	20	200	8	<0.10	20	<0.50	9.9	411
	5/18/97	8940	23	<1	110	21	210	8	<0.10	13	<0.50	6.4	315
	5/19/97	8910	21	<1	92	16	180	8	<0.10	13	<0.50	4.3	244
	5/19/97	8880	20	<1	85	14	150	8	<0.10	12	<0.50	9.3	207
	5/20/97	8180	17	<1	66	11	110	8	<0.10	11	<0.50	8.8	169
	5/21/97	7760	14	<1	49	9	90	7	<0.10	10	<0.50	9.9	126
	5/22/97	7770	13	<1	42	8	80	8	<0.10	9.7	<0.50	7	128
	5/23/97	7530	12	<1	48	7	70	6	0.13	10	<0.50	6.2	108
	6/1/97	9410	18	<1	87	15	150	7	<0.10	11	<0.50	6.2	336
	6/2/97	9650	20	<1	100	17	180	9	<0.10	13	0.76	4.2	326
	6/2/97	9560	22	<1	86	15	150	8	<0.10	12	<0.50	6.3	244
	6/3/97	9030	18	<1	70	10	110	9	<0.10	13	<0.50	5.9	202
	6/4/97	8620	16	<1	57	9	90	8	<0.10	12	<0.50	9.3	151
	6/22/97	5670	18	<1	43	6	60	13	0.11	8.9	<0.50	7.2	64
	Average	7934	18	<1	74	13	131	8	<0.10	12	<0.50	7	236
BFR at Bonner	5/19/97	13400	3	<1	8	3	<10	1	<0.10	2.2	<0.50	<3.0	212
	6/5/97	11800	2	<1	34	2	<10	1	<0.10	1.8	<0.50	<3.0	157
	6/55/97	5130	<1	<1	3	<1	<10	1	<0.10	1	<0.50	3	23
	Average	10110	3	<1	15	3	<10	1	<0.10	1.7	<0.50	<3.0	130.7

Notes:

1. Values for arsenic are total concentration, values for cadmium, copper, lead and zinc are total recoverable concentration.

CFR - Clark Fork River, cfs - cubic feet per second, ppb - parts per billion, ppm - parts per million, TSS - Total Suspended Sediment.

Daily discharge values are calculated by multiplying instantaneous concentration by corresponding stream flow rate then converting to appropriate units.

Data from U.S. Geological Survey.

**Table 1-4 (continued)**  
**Surface Water Quality During Spring 1997 Flood Event for Clark Fork and Blackfoot Rivers**  
**Milltown Reservoir Focused Feasibility Study**

Location	Date	Discharge (cfs)	Total Recoverable (ppb)					Dissolved (ppb)					TSS (ppm)
			Arsenic	Cadmium	Copper	Lead	Zinc	Arsenic	Cadmium	Copper	Lead	Zinc	
CFR above Missoula (East Missoula)	5/13/97	16800	10	<1	47	10	100	4	<0.10	5	<0.50	3.5	182
	5/14/97	17200	8	<1	37	7	60	4	<0.10	5.1	<0.50	<3.0	272
	5/15/97	20500	10	<1	42	10	100	4	<0.10	5.1	<0.50	<3.0	360
	5/16/97	23100	14	<1	62	13	120	4	<0.10	6.6	<0.50	<3.0	436
	5/18/97	26300	14	<1	63	14	130	4	<0.10	6.4	<0.50	<3.0	518
	5/19/97	23800	12	<1	53	11	120	4	<0.10	6.4	<0.50	4	38
	5/20/97	21200	10	<1	50	9	90	4	<0.10	5.6	<0.50	3.7	260
	5/20/97	20200	9	<1	36	7	70	4	<0.10	6.1	<0.50	4.8	212
	5/21/97	18500	8	<1	30	5	60	4	<0.10	5.4	<0.50	<3.0	146
	5/22/97	17400	7	<1	24	4	50	4	<0.10	5.5	<0.50	8.3	124
	5/23/97	17000	6	<1	23	4	40	3	<0.10	5.9	<0.50	6.5	106
	6/1/97	20000	8	<1	39	7	60	3	<0.10	7.8	<0.50	4.2	173
	6/2/97	20700	10	<1	45	9	80	4	<0.10	6.5	<0.50	7.9	182
	6/2/97	20700	11	<1	49	9	80	4	<0.10	6.5	<0.50	4.7	187
	6/3/97	18700	9	<1	38	6	60	5	<0.10	7.1	<0.50	<3.0	129
	6/4/97	17800	7	<1	27	5	50	4	0.12	6.6	<0.50	7.6	97
	6/22/97	9940	9	<1	22	3	30	7	<0.10	4.4	<0.50	<3.0	37
Average		18919	9	<1	39	8	73	4	0	6	<0.50	6	212

Notes:

1. Values for arsenic are total concentration, values for cadmium, copper, lead and zinc are total recoverable concentration.

CFR - Clark Fork River, cfs - cubic feet per second, ppb - parts per billion, ppm - parts per million, TSS - Total Suspended Sediment.

Daily discharge values are calculated by multiplying instantaneous concentration by corresponding stream flow rate then converting to appropriate units.

Data from U.S. Geological Survey.

**Table 1-5**  
**Surface Water Quality During February 1996 Ice Scour Event for Clark Fork River and Milltown Reservoir**  
**Milltown Reservoir Focused Feasibility Study**

Sampler	Location	Date	Time	Discharge (cfs)	Total (ppb)				Dissolved (ppb)				TSS (ppm)
					Arsenic (ppb)	Cadmium (ppb)	Copper (ppb)	Zinc (ppb)	Arsenic (ppb)	Cadmium (ppb)	Copper (ppb)	Zinc (ppb)	
USGS	CFR below Milltown Dam	2/9/96	9:30	9,080	69	5	400	1,100	9	<1	11	15	824
Missoula Co.	CFR below Milltown Dam	2/9/96	10:30	NA	54	4	440	1,000	11	<1	<10	30	NA
Missoula Co.	CFR below Milltown Dam	2/10/96	15:25	NA	73	6	680	1,220	11	1	30	30	NA
Missoula Co.	CFR below Milltown Dam	2/10/96	NA	NA	69	5	630	1,140	11	2	30	40	NA
Missoula Co.	CFR below Milltown Dam	2/10/96	NA	NA	97	7	770	1,310	12	1	20	30	NA
Missoula Co.	Milltown Reservoir	2/10/96	16:35	NA	19	2	310	480	5	2	20	20	NA
USGS	CFR at Turah Bridge	2/11/96	11:00	4340	23	<1	180	110	13	<0.1	11	22	100

**Notes:**

Data from: United States Geological Survey and Missoula City-County Health Department

USGS - United States Geological Survey

CFR - Clark Fork River

cfs - cubic feet per second

ppb - parts per billion

ppm - parts per million

NA - Not Available

TSS - Total Suspended Sediment

< - Indicates "non-detect" to the level indicated.

**Table 3-1**  
**Summary of Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Milltown Reservoir Sediments Site**

Federal Contaminant Specific ARARs	Applicable or Relevant and Appropriate Portion
Safe Drinking Water Act	40 CFR Part 141; 40 CFR Part 264; 40 CFR 300.430 (e)(2)(i)(B).
Federal Location Specific ARARs	Applicable or Relevant and Appropriate Portion
Fish and Wildlife Coordination Act	16 USC 1531 - 1566; 40 CFR 6.302(g).
Floodplain Management Order	40 CFR Part 6, Appendix A; Executive Order 11,988.
Protection of Wetlands Order	40 CFR Part 6, Appendix A; Executive Order 11,990.
Endangered Species Act	16 USC 1531 - 1543; 50 CFR Part 402; 40 CFR 6.302(h).
National Historic Preservation Act	16 USC 470; 40 CFR 6.310(b); 36 CFR Part 800.
Archeological and Historic Preservation Act	16 USC 469; 40 CFR 6.301(c)
Historic Sites, Buildings and Antiquities Act	36 CFR 62.6(d).
Migratory Bird Treaty Act	16 USC 703 et seq.
Bald Eagle Protection Act	16 USC 668 et seq.
Resource Conservation and Recovery Act (RCRA)	40 CFR 264.18(a) and (b).

**Table 3-1 (continued)**  
**Summary of Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Milltown Reservoir Sediments Site**

Federal Action Specific ARARs	Applicable or Relevant and Appropriate Portion
Solid Waste Disposal Act as amended by RCRA	42 USC 6901 et seq.; 40 CFR 257.3-1(a), 3-3, and 3-4.
Surface Mining Control and Reclamation Act	30 USC Sections 1201-1326; 30 CFR Parts 816 and 784;
RCRA	40 CFR 264.116 and 119; 40 CFR 264.228(a)(2)(i); 40 CFR 264.228(a)(2)(iii)(B), (C), and (D); 40 CFR 264.251(c), (d), and (f).
Clean Air Act	42 USC 7401 et seq.; 40 CFR 50.12; 40 CFR 50.6; 40 CFR Part 50.
Clean Water Act	40 CFR Parts 121, 122 and 125; 40 CFR 122.44(i); 40 CFR 440.148.
Dredge and Fill Requirements	40 CFR Part 230.
Underground Injection Control	40 CFR Part 144.
Transportation of Hazardous or Contaminated Waste	40 CFR Part 263.
Federal Energy and Regulatory Commission Requirements	16 USC Sections 797, 799, and 803 (a); 18 CFR Part 12.
Montana Contaminant Specific ARARs	Applicable or Relevant and Appropriate Portion
Surface Water Quality Standards	MCA 75-5-101 et seq.; ARM 16.20.604(1); ARM 16.20.618; ARM 16.20.633; ARM 16.20.925; WQB-7.
Ground Water Quality Standards	MCA 75-6-101 et seq.; ARM 16.20.204; ARM 16.20.1002, 1003, and 1011; MCA 75-5-303; ARM 16.20.706 et seq.; WQB-7.

**Table 3-1 (continued)**  
**Summary of Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Milltown Reservoir Sediments Site**

Montana Location Specific ARARs	Applicable or Relevant and Appropriate Portion
Floodplain and Floodway Management Act and Regulations	MCA 76-5-401; ARM 36.15.101(13); ARM 36.15.601, 602 (1) and (6), 603, 604, and 606; ARM 36.15.605(2), 703; ARM 36.15.216; MCA 76-5-406; ARM 36.15.701, MCA 76-5-402; ARM 36.15.702(1)(2).
Solid Waste Management Regulations	ARM 16.14.505; ARM 16.44.503(1)(b); MCA 75-10-201 et seq.; MCA 75-10-212
Natural Streambed and Land Preservation Standards	MCA 87-5-502, 504; ARM 36.2.404; MCA 75-7-102.
Montana Action Specific ARARs	Applicable or Relevant and Appropriate Portion
Water Quality Statute and Regulations	MCA 75-5-605; MCA 75-5-103(19); MCA 75-5-303; MCA 75-5-308; MCA 75-5-317; ARM 16.20.708; ARM 16.20.711; ARM 16.20.1011; ARM 16.20.706 et seq.; ARM 26.4.633; ARM 16.20.1314.
Montana Pollutant Discharge Elimination System	ARM 16.20.1318; ARM 16.20.1319; ARM 16.20.1320;
Air Quality Regulations	MCA 75-2-101 et. seq.; ARM 16.8.818; ARM 26.4.761; ARM 16.8.1301(5), 1302, 1307, 1308; ARM 16.8.1401 (1), 1401(2), 1404.

**Table 3-1 (continued)**  
**Summary of Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Milltown Reservoir Sediments Site**

Montana Action Specific ARARs (Continued)	Applicable or Relevant and Appropriate Portion
Solid Waste Management Regulations	ARM 16.14.505; ARM 16.14.502(25); ARM 16.14.506; ARM 16.14.521; ARM 16.14.530-531.
Reclamation Activities - Hydrology Regulations	MCA 82-4-201 et seq.; ARM 26.4.631; ARM 26.4.633; ARM 26.4.634; ARM 26.4.635-637; ARM 26.4.640.
Reclamation and Revegetation Requirements	ARM 26.4.501, 501A; ARM 26.4.514; ARM 26.4.519; ARM 26.4.638; ARM 26.4.701; ARM 26.4.702; ARM 26.4.703; ARM 26.4.711; ARM 26.4.713; ARM 26.4.714; ARM 26.4.716; ARM 26.4.718; ARM 26.4.728.
Dam Safety Requirements	MCA 85-15-101 et seq.; MCA 85-15-208; ARM 36.14.401; ARM 36.14.405; ARM 36.14.501; ARM 36.14.502.

**Table 3-1 (continued)**  
**Summary of Applicable or Relevant and Appropriate Requirements (ARARs)**  
**Milltown Reservoir Sediments Site**

"Other Laws" (Non-Exclusive List)	Applicable or Relevant and Appropriate Portion
<u>Federal:</u>	
Federal Occupational Safety and Health Regulations	29 CFR 1910.
<u>Montana:</u>	
Montana Ground Water Act	MCA 85-2-516; MCA 85-2-505.
Montana Water Rights	MCA 85-2-101; MCA 85-3 and 4; MCA 85-2-301; MCA 85-2-302; MCA 85-2-306; MCA 85-2-311; MCA 85-2-402; MCA 85-2-412.
Montana Occupational Health Act	MCA 50-70-101 et seq.; ARM 16.42.101; ARM 16.42.102.
Montana Safety Act	MCA 50-71-201, 202, and 203.
Montana Employee and Community Hazardous Chemical Information Act	MCA 50-78-201, 202, and 204.
Montana Public Water Supply Regulations	ARM 16.20.401(3).

Notes:

Ref: U.S. Environmental Protection Agency, 1995, "Identification and Description of Applicable or Relevant and Appropriate Requirements for Feasibility Study Analyses of Alternatives, Milltown Reservoir/Clark Fork River NPL Site, Reservoir Sediments Operable Unit", October.

ARARs - Applicable or Relevant and Appropriate Regulations

ARM - Administrative Rules of Montana

MCA - Montana Code, Annotated

CFR - Code of Federal Regulations

USC - United States Code

EO - Executive Order

WQB - Water Quality Bureau

**Table 4-1**  
**Remedial Alternative Technology Options**  
**Milltown Reservoir Sediments Site**

Alternative	Activity	Technology Options
1. No Action	No additional activities	Not Applicable
2. Institutional Controls (ICs)	Enact Restrictions	Ground water use restrictions Land use restrictions Dam operating restrictions
3. In-situ Treatment	Addition of Chemical Stabilization Agent	Addition of gypsum Injection of sodium sulfide Injection of calcium sulfide Injection of sodium bisulfide Injection of ferrous sulfate Injection of air or oxygen
4. In-situ Sediments Flushing	Injection of Flushing Liquid	Water injection Acid injection EDTA injection
5. Ground Water Extraction and Treatment	Ground Water Extraction	Pumping wells Extraction trench Drainfield
	Ground Water Treatment	Coagulation - Alum - Ferric sulfate - Ferric chloride
		Chemical precipitation - Lime - Sodium hydroxide (caustic) - Sulfide
		Ion exchange - Polymer resins - Biological media
		Reverse osmosis or electrodialysis
6. Ground Water Containment	Barrier Construction	Physical barrier - Slurry wall - Grout curtain - Sheet pile cutoff wall
		Hydraulic barrier - Injection wells - Infiltration galleries

**Table 4-1 (continued)**  
**Remedial Alternative Technology Options**  
**Milltown Reservoir Sediments Site**

Alternative	Activity	Technology Options
7. Sediment Removal and Disposal (Total or Partial)	Sediment Removal	Hydraulic dredging Mechanical dredging
8. Total or Partial Sediment Removal, Treatment and Disposal	Sediment Removal	Hydraulic dredging Mechanical dredging
	Sediment Treatment	Solidification/Stabilization - Cement - Lime - Fly ash
		Soil washing - Physical size separation - Water washing - Acid washing - EDTA washing
9. Sediment/Channel Stabilization	Apply Cap, Cover or Seal, and Divert River	Asphalt cap Concrete cap Soil cement cap Synthetic membrane cover Sealant or grout injection or cover Construct bypass channel
10. Source Controls	Divert River	Construct bypass channel
11. Dam Engineering	Remove Dam	Demolish Milltown Dam
	Raise Dam	Raise sluiceway and dam crest

**Table 4-2**  
**Relative Performance of Remedial Alternatives Evaluated During Screening Analysis**  
**Milltown Reservoir Sediments Site**

Remedial Action Alternatives	Evaluation Criteria				Retain for Detailed Analysis
	Long-Term Effectiveness	Short-Term Effectiveness	Implementability	Costs	
1. No Action	○	●	●	●	Yes
2. Institutional Controls	●	●	●	●	Yes
3. In-Situ Treatment	○	○	○	●	No
4. In-Situ Sediment Flushing	○	○	○	●	No
5. Ground Water Extraction and Treatment	●	○	●	○	No
6. Ground Water Containment	●	○	○	●	No
7. Sediment Removal and Disposal	●	○	○	○	No
8. Sediment Removal, Treatment and Disposal	●	○	○	○	No
9. Sediment/Channel Stabilization	●	○	○	○	No
10. Source Controls	○	○	○	○	No
11a. Dam Engineering (Dam Raising)	○	○	○	○	No
11b. Dam Engineering (Dam Removal)	●	○	○	○	No
12. ICs and In-Situ Treatment	●	○	○	●	No
13. In-Situ Treatment with Ground Water Extraction and Treatment	●	○	○	○	No
14. ICs and Dam Engineering (Dam Raising)	●	○	○	○	No
15. ICs, In-Situ Treatment, and Ground Water Extraction and Treatment	●	○	○	○	No
16. ICs, Ground Water Containment and In-Situ Treatment	●	○	○	○	No
17. In-Situ Flushing with Ground Water Extraction and Treatment	●	○	○	○	No
18. ICs, Partial Removal with Treatment and Disposal, In-Situ Treatment, Ground Water Extraction/Treatment	●	○	○	○	No
19. ICs, Partial Removal with Treatment and Disposal, In-Situ Treatment, Ground Water Extraction/Treatment	●	○	○	○	No
20. ICs, Sediment Removal and Disposal and Ground Water Natural Attenuation	●	○	○	○	Yes
21. ICs, Sediment Removal and Disposal and Ground Water Extraction/Treatment	●	○	○	○	Yes
22. ICs, and Ground Water Containment, and Ground Water Natural Attenuation	●	●	○	●	Yes
23. ICs, Ground Water Containment and Ground Water Extraction/Treatment	●	●	○	○	Yes

Legend

- High achievement of the criteria.
- Moderate achievement of the criteria.
- Little or no achievement of the criteria.

**Table 4-3**  
**Relative Performance of Remedial Alternatives Evaluated in the 1996 Feasibility Study**  
**Milltown Reservoir Sediments Site**

	CRITERIA							Total
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, or Volume Through Treatment	Short-Term Effectiveness	Implementability	Cost	
Alternative 1	0							<b>0<sup>(1)</sup></b>
Alternative 2	3	2	3	0	4	3	3	<b>18</b>
Alternative 3	3	2	4	2	1	1	1	<b>14</b>
Alternative 4	3	2	4	3	1	1	0	<b>14</b>
Alternative 5	3	1	2	1	2	2	2	<b>13</b>
Alternative 6	3	1	2	2	3	1	0	<b>12</b>
Alternative 7	3	1	2	2	1	1	1	<b>11</b>
Alternative 8	3	1	3	3	1	1	0	<b>12</b>

Notes:

- 0 - Low achievement of the criterion by this alternative compared to other alternatives.
- 1 - Moderately low achievement of the criterion by this alternative compared to other alternatives.
- 2 - Moderate achievement of the criterion by this alternative compared to other alternatives.
- 3 - Moderately high achievement of the criterion by this alternative compared to other alternatives.
- 4 - High achievement of the criterion by this alternative compared to other alternatives.

(1) Fails to meet threshold criteria.

**Table 4-4**  
**Relative Performance of Remedial Alternatives Evaluated in the Focused Feasibility Study**  
**Milltown Reservoir Sediments Site**

Alternatives	Comparative Analysis of Remedial Alternatives <sup>(1)</sup>							
	Threshold Criteria		Balancing Criteria					Overall Score
	Overall Protection of Human Health and the Environment (2)	Compliance with ARARs (2)	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume Through Treatment	Short-Term Effectiveness	Implementability	Capital / Operating and Maintenance Cost	
1 No Further Action	Not Protective	NR	NR	NR	NR	NR	NR	NR
2 Modification of Dam and Operational Practices	4	3	3	2	5	5	5	27
3a Erosion/Scour Protection	4	3	3	2	5	4	4	25
3b Modification of Dam and Operational Practices with Channelization	3	3	3	3	3	3	3	21
4 Periodic Sediment Removal	3	4	3	3	3	3	3	22
5 Dam Removal, Partial Sediment Removal (Lower Reservoir Area) with Channelization, Leachate Collection/Treatment	3	3	2	3	3	3	2	19
6a Total Sediment Removal (Lower Reservoir Area)	3	4	4	4	2	3	2	22
6b Total Sediment Removal (Entire Reservoir Area)	3	4	4	4	2	3	1	21
7a Dam Removal and Total Sediment Removal (Lower Reservoir Area)	4	3	5	4	2	3	2	23
7b Dam Removal and Total Sediment Removal (Entire Reservoir Area)	4	3	5	4	2	2	1	21

**Notes:**

NR = Not Rated

1. Alternatives are numerically scored based on relative achievement of the criterion compared to other alternatives using the following ranking system: 1 = low achievement;

2 = low to moderate achievement; 3 = moderate achievement; 4 = moderate to high achievement and 5 = high achievement. See Tables 5-1 and 5-2 for achievement bases.

2. Groundwater ARARS compliance & effectiveness/protectiveness evaluations are not included in the FFS. These evaluations will be performed for final alternatives in the combined FS Report.

**Table 4-5**  
**Overview of Retained Remedial Alternatives**  
**Milltown Reservoir Combined Feasibility Study**

<b>Alternative</b>	<b>Action to Dam<sup>(1)</sup></b>	<b>Action to Channel and Floodplain Sediments</b>	<b>Action to Groundwater Plume</b>
1 - No Further Action	Safety Upgrade/Fish Passage	None	Maintain Replacement Water Supply
Alternative 2A - Modification of Dam and Operational Practices plus GW ICs	Safety Upgrade/Fish Passage/Inflatable Rubber Dam	Scour Management	Maintain Replacement Water Supply/Controlled Groundwater Area
Alternative 2B - Modification of Dam and Operational Practices plus GW ICs and Containment and Natural Attenuation within Aquifer Plume	Safety Upgrade/Fish Passage/Inflatable Rubber Dam	Scour Management	Slurry Wall, plus actions listed above for 2A
Alternative 3A - Modification of Dam and Operational Practices with Scour Protection plus GW ICs	Safety Upgrade/Fish Passage/Inflatable Rubber Dam	Soft Streambank Stabilization and Revegetation	Same as 2A above
Alternative 3B - Modification of Dam and Operational Practices with Channelization plus GW ICs and Containment and Natural Attenuation within Aquifer Plume	Safety Upgrade/Fish Passage/Inflatable Rubber Dam	Limited Sediment Removal/Channelization with Armoring Plus Periodic Maintenance Removal	Same as 2B above
Alternative 5 - Dam Removal, Partial Sediment Removal with Channelization and Leachate Collection/Treatment, plus GW ICs and Natural Attenuation within Aquifer Plume	Removal	Limited Sediment Removal in Channels with Armoring	Leachate Collection/Maintain Replacement Water Supply/Controlled Groundwater Area
Alternative 6A - Modification of Dam and Operational Practices with Initial Total Sediment Removal of the Lower Reservoir Area and Periodic Sediment Removal Thereafter, plus GW ICs and Natural Attenuation within Aquifer Plume	Safety Upgrade/Fish Passage/Inflatable Rubber Dam	Total Sediment Removal Below Duck Bridge Plus Periodic Maintenance Removal	Source Removal/Maintain Replacement Water Supply/Controlled Groundwater Area/Eventual Groundwater Cleanup Possible
Alternative 6B - Modification of Dam and Operational Practices with Total Sediment Removal of the Entire Reservoir and Periodic Sediment Removal Thereafter, plus GW ICs and Natural Attenuation within Aquifer Plume	Safety Upgrade/Fish Passage/Inflatable Rubber Dam	Total Sediment Removal Entire Reservoir Plus Periodic Maintenance Removal (Lower Reservoir Only)	Same as 6A above
Alternative 7A1 - Dam Removal with Total Sediment Removal of the Lower Reservoir Area plus GW ICs and Natural Attenuation within Aquifer Plume	Removal	Total Sediment Removal below Duck Bridge with Channel and Floodplain Reconstruction	Same as 6A above
Alternative 7A2 - Dam Removal and Partial Sediment Removal of the Lower Reservoir Area plus GW ICs and Natural Attenuation within Aquifer Plume	Removal	Partial Sediment Removal below Duck Bridge with Channel and Floodplain Reconstruction	Same as 6A above
Alternative 7B - Dam Removal with Total Sediment Removal of the Entire Reservoir plus GW ICs and Natural Attenuation within Aquifer Plume	Removal	Total Sediment Removal Entire Reservoir with Channel and Floodplain Reconstruction	Same as 6A above

Notes:

1. Dam modifications involve: upgrading the dam to withstand the probable maximum flow; installing a fish ladder or performing trap-and-haul for fish passage; and installing an inflatable rubber dam (i.e. pneumatic crest gate) to replace the existing flashboard assembly and associated super structure to provide improved control of reservoir pool elevation.

N/A = not applicable

**Table 4-6**  
**Estimated Volumes for Sediment Removal Alternatives**  
**Milltown Reservoir Combined Feasibility Study**

<b>Alternative</b>	<b>In-Place Removal Volume</b> (million cubic yards)	<b>Contingency on In-Place Volume (30%)</b> (million cubic yards) <sup>(1)</sup>	<b>Annual Incoming Sediments</b> (cubic yards.)	<b>Additional Volume for Incoming Sediments During Initial Removal</b> (million cubic yards) <sup>(2)</sup>	<b>Total Volume for Initial Removal</b> (million cubic yards)	<b>Periodic Removal Volume</b> (million cubic yards) <sup>(3)</sup>	<b>Typical Periodic Removal Return Time</b> (years)
3B	0.48	0.14	85,000	0.06	0.7	0.4	4
5	0.48	0.14	85,000	0.06	0.7	-	-
6A	3.84	1.15	85,000	0.21	5.2	2.6	19
6B	6.60	1.98	85,000	0.36	8.9	2.6	18
7A1	3.84	1.15	85,000	0.21	5.2	-	-
7A2	3.08	0.92	85,000	0.18	4.2	-	-
7B	6.60	1.98	85,000	0.36	8.9	-	-

**Note:**

1. A 30% contingency is applied to the in-place removal volume to account for accuracy limitations of available in-place volume estimate, sloughing of additional sediments into the removal area and the potential need for over excavation.

2. The additional volume of incoming sediments that occurs over the duration of removal activities is based on sediment input rate of approximately 142,000 tons per year (converted into 85,000 in-place cubic yards per year volume using an assumed dry density of 1 in-place cy/0.6 tons of sediment input. It is estimated that approximately 35% of the incoming sediment could potentially settle in the reservoir and get incorporated into the removal during construction activities.

The duration of sediment removal activities is approximately 2 seasons for alternatives 3B and 5; 6 seasons for Alternative 7A2; 7 seasons for alternatives 6A and 7A; and 12 seasons for alternatives 6B and 7B (Table 4-6). The 142,000 tons per year sediment input rate is based on 1991-1997 period annual average total suspended sediment loading to Milltown Reservoir from the Clark Fork River (measured at Turah) and the Blackfoot River (measured near Bonner) presented in *Estimated 1996-97 and Long-Term Average Annual Loads for Suspended Sediment and Selected Trace Metals in Streamflow of the Upper Clark Fork Basin from Warm Springs to Missoula, Montana. USGS 1998*.

The percent deposition of incoming sediments for each alternative is based on a "Conceptual Sediment Basin Removal Efficiency Calculation" included in Appendix D5 which estimated that up to 41% of the combined amount of incoming sediments from the CFR and BFR are deposited in a basin created by a removal of reservoir sediments located upstream of the dam for Alternative 3B. TSS removal efficiency for Alternative 6A is calculated to be 59% for the combined CFR and BFR input while TSS removal efficiency for Alternative 6B is calculated to be 62% for the combined CFR and BFR input.

3. The periodic removal volume for Alternatives 3B is estimated to be approximately 350,000 cy. Periodic removal volumes for Alternatives 6A and 6B are approximately 2,600,000 cy. Removal timeframes are based on the estimated number of years to re-accumulate these volumes given the combined CFR and BFR TSS removal efficiencies for each alternative with a periodic removal component (Alternative 3B, 6A and 6B) (Appendix D-5). The removal return times used for costing Alternatives 6A and 6B are rounded off to 20 years. Periodic removal volumes and timeframes determined based on capture efficiency calculations may overestimate actual amounts of sediment that re-accumulate because the capture efficiency calculations do not consider the potential for periodic scour of re-accumulated sediments during high flow events.

**Table 4-7**  
**Implementation Timeframes for Sediment Removal Alternatives**  
**Milltown Reservoir Combined Feasibility Study**

Item	Quantity	Unit
Hydraulic Dredge Production Rate <sup>(1)</sup>	3,552	cubic yards/day
Construction Season <sup>(1)</sup>	150	days
Conventional Equipment Production <sup>(2)</sup>	2,500	cubic yards/day
Construction Season <sup>(2)</sup>	150	days
<b>Alternatives 3B and 5 - Limited Sediment Removal</b> <b>(For Channelization or Sediment Basin)</b>		
Removal Volume (with contingency and incoming sediments)	0.7	million cubic yards/day
Duration of Dredge Sediment Removal Activities	197	construction days
<b>Duration of Sediment Removal Activities <sup>(3)(4)</sup></b>	<b>2</b>	<b>seasons</b>
<b>Alternatives 6A and 7A1 - Total Sediment Removal (with road or rail sediment transport)</b> <b>(Lower Reservoir)</b>		
Removal Volume (with contingency and incoming sediments)	5.2	million cubic yards/day
Duration of Dredge Sediment Removal Activities	732	construction days
Duration of Conventional Sediment Removal Activities	1040	construction days
<b>Duration of Sediment Removal Activities <sup>(3)(4)(5)</sup></b>	<b>7</b>	<b>seasons</b>
<b>Alternative 7A2 - Partial Sediment Removal (with road or rail sediment transport)</b> <b>(Lower Reservoir)</b>		
Removal Volume (with contingency and incoming sediments)	4.2	million cubic yards/day
Duration of Dredge Sediment Removal Activities	589	construction days
Duration of Conventional Sediment Removal Activities	837	construction days
<b>Duration of Sediment Removal Activities <sup>(3)(4)(5)</sup></b>	<b>6</b>	<b>seasons</b>
<b>Alternatives 6B and 7B - Total Sediment Removal (with road or rail sediment transport)</b> <b>(Entire Reservoir)</b>		
Removal Volume (with contingency and incoming sediments)	8.9	million cubic yards/day
Duration of Dredge Sediment Removal Activities	1253	construction days
Duration of Conventional Sediment Removal Activities	1780	construction days
<b>Duration of Sediment Removal Activities <sup>(3)(4)(5)</sup></b>	<b>12</b>	<b>seasons</b>

**Notes:**

1. Estimated hydraulic dredge production rates used to determine implementation timeframes and volumes are based on the USACE September 20, 2000 Evaluation of Dredging Costs (Appendix I1 to the FFS) and revised in accordance with the USACE comments in Appendix H1 to the FFS. Dredge production rates are based on a 12 inch cutter - suction dredge with a dredging rate of 296 cubic yards/hour. Dredge operation assumes 24 hour/day operation with 50 percent efficiency (i.e., 12 operating hours/day). Construction season for hydraulic dredging is assumed to start after completion of spring high flow and continue through late fall (i.e. approximately July through November).
2. Conventional equipment (i.e., scrapers, dozers/loaders and excavators) used for the removal of dewatered sediments is assumed for 50 percent of total removal under Alternatives 6A, 6B, 7A1, 7A2, and 7B road or rail sediment transport options (Appendix D5-3). No conventional sediment equipment removal is assumed in determining the implementation timeframes under Alternatives 3B and 5 (it is recognized that mechanical dredging using draglines or clam shell excavators may be required to support debris removal during hydraulic dredging but no additional production is assigned to this when estimating implementation timeframes). The 2,500 cubic yards per day for conventional equipment production is based on AERL's experience during the Lower Area One (LAO) removal (which averaged approximately 2,200 cubic yards per day). Construction season for conventional equipment is assumed to occur during low water level conditions during the summer and fall to maximize the amount of passively dewatered sediments (Appendix D5-3).
3. Duration of sediment removal activities assumes that transportation of sediments by either truck or slurry pipeline would be able to keep pace with production rates. Dam removal, floodplain reconstruction and/or channelization would extend total project duration by an additional 1 to 2 years after completion of sediment removal activities for Alternatives 5, 7A1, 7A2 and 7B.
4. Rail haul of removed sediments may increase the project duration due to potential restrictions on rail use (note: LAO removal was only able to achieve a rail transport rate of 1,870 cy/day).
5. It is likely that dredge and conventional sediment removal activities will occur concurrently under the total removal alternatives for road or rail haul options. Therefore, the number of seasons is based on the construction days for the longest duration of the two methods evaluated. For simplicity, the same sediment removal duration is assumed for the slurry transport option under total removal as was calculate for road or rail haul options (i.e. the production rate lost by not including concurrent conventional equipment removal is assumed to be offset by increasing the size or number of hydraulic or mechanical dredges).

**Table 4-8**  
**Removal, Transportation and Disposal Options for Sediment Removal Alternatives**  
**Milltown Reservoir Combined Feasibility Study**

Disposal Location	Transportation Distance From Site (miles)	Removal Method	Mechanical Dewatering	Trucking	Rail	Slurry Pipeline	Decant Dewatering	Water Treatment Plant Required for Sediment Water ?	Disposal Site Capacity	Infrastructure Status
<i>Near Reservoir (Upstream B)</i>	3	Wet	N	N	N	Y	Y	Y <sup>(1)</sup>	Adequate <sup>(2)</sup>	slurry line needed protective floodway berm needed
<i>Missoula County Dry Repository Site (Hypothetical) <sup>(3)</sup></i>	10-20	Dry	Y <sup>(4)</sup>	Y	Y	N	NA	Y <sup>(4)</sup>	?	on-site haul roads needed <u>or</u> on-site and repository rail spurs needed
	10-20	Wet	Y	Y	Y	N	NA	Y	?	on-site haul roads needed <u>or</u> on-site and repository rail spurs needed
<i>BFI Landfill</i>	10	Dry	Y <sup>(4)</sup>	Y	Y	N	NA	Y <sup>(4)</sup>	?	on-site haul roads needed <u>or</u> on-site and BFI rail spurs needed
	10	Wet	Y	Y	Y	N	NA	Y	?	on-site haul roads needed <u>or</u> on-site and BFI rail spurs needed
<i>Opportunity Ponds <sup>(5)</sup></i>	110 - 120	Dry	Y <sup>(4)</sup>	N	Y	N	NA	Y <sup>(4)</sup>	Adequate	on-site rail spur needed
	110 - 120	Wet	Y	N	Y	N	NA	Y	Adequate	on-site rail spur needed

**Notes:**

1. Water treatment is assumed for decant water from slurried sediment disposal facility because decant water quality is unlikely to meet WQB-7 surface water quality standards without treatment.
2. Adequacy of near reservoir Upstream B potential disposal site for all removal volume alternatives assumes capacity availability and suitability of most or all of the site (part of which is currently occupied by a wood waste/compost pile, a gravel pit and other developments and another part of which is located within the 100-year floodplain of the CFR). Capacity adequacy could also be affected by repository maximum height limitations if applicable.
3. Other Missoula County Site locations may be designated by the County. A ten to twenty mile transportation distance is assumed for these hypothetical sites because a previous preliminary repository siting study (Appendix D3-2) did not identify potentially suitable sites within 10 miles of the reservoir.
4. Some mechanical dewatering and water treatment is assumed for dry (i.e. mechanical) sediment removal because mechanically removed sediments are unlikely to be sufficiently dry to meet paint filter test requirements without some dewatering which would generate water requiring treatment. However, the relative amount of water generated would be reduced compared to wet (i.e. hydraulic) removal (See Table 4-5). Dry sediment removal is only an option for the total removal Alternatives 6A, 6B, 7A, and 7B. Even under these alternatives it is assumed that only 50% of the sediments will passively dewater sufficiently in place to allow "dry" removal using conventional excavation equipment.
5. Opportunity Ponds transportation distance by rail assumes connecting to Rarus track at Port of Montana.

N = No  
Y = Yes  
NA = Not Applicable

**Table 4-9**  
**Water Budgets for Sediment Dewatering and Water Treatment**  
**Milltown Reservoir Combined Feasibility Study**

<b>Hydraulic Dredge Excavation (1)</b>		
In-place material removal rate (1)	3,552 cubic yards/day	(calculated based on 296 cubic yards per hour, operating 24 hours per day at 50% efficiency or 12 hours of actual production per day)
Percent solids of removed material	15	(input)
Water generated per day (2)	4,065,323 gallons/day	(3552 cubic yards per day / 0.15 solids)*(1-0.15 solids)*(27cubic feet per cubic yard) *(7.4805 gallons per cubic foot)
<b>Conventional Equipment Excavation (3)</b>		
In-place material removal rate (3)	2,500 cubic yards/day	(input)
Percent solids of removed material	70	(input)
Water generated per day (2)	151,480 gallons/day	(2500 cubic yards per day)*(1-0.7 solids)*(27cubic feet per cubic yard)*(7.4805 gallons per cubic feet)
<b>Alternatives 3B and 5 - Limited Sediment Removal (0.7 million cubic yards) (4)</b>		
Volume of water generated from hydraulically dredged sediments	4,065,323 gallons/day	
Total volume of water generated (5)	800,868,554 gallons	(197 days * 4,065,323 gallons per day)
<b>Alternatives 6A and 7A1 - Total Sediment Removal with Road or Rail Sediment Transport(Lower Reservoir, 5.2 million cubic yards) (4)</b>		
Volume of water generated from hydraulically dredged sediments (50% of sediments) (5)	2,975,816,149 gallons	(732 days* 4,065,323 gallons per day)
Volume of water generated from mechanically dredged sediments (50% of sediments) (5)	157,539,330 gallons	(1,040 days*151,480 gallons per day)
Total volume of water generated per day	4,216,803 gallons/day	(4,065,323 gallons per day hydraulic + 151.480 gallons per day conventional)
Total volume of water generated	3,133,355,479 gallons	
<b>Slurry Transport Option</b>		
Total volume of water generated with hydraulic dredge of 100% of sediments (5)	5,951,632,298 gallons	(732 days* 2*4,065,323 gallons per day)
<b>Alternatives 6B and 7B - Total Sediment Removal with Road or Rail Sediment Transport(Entire Reservoir, 8.9 million cubic yards) (4)</b>		
Volume of water generated from hydraulically dredged sediments (50% of sediments) (5)	5,093,849,228 gallons	(1253 days* 4,065,323 gallons per day)
Volume of water generated from mechanically dredged sediments (50% of sediments) (5)	269,634,623 gallons	(1,780 days*151,480 gallons per day)
Volume of water generated per day	4,216,803 gallons/day	(4,065,323 gallons per day hydraulic + 151.480 gallons per day conventional)
Total volume of water generated	5,363,483,850 gallons	
<b>Slurry Transport Option</b>		
Total volume of water generated with hydraulic dredge of 100% of sediments (5)	10,187,698,456 gallons	(1253 days*2* 4,065,323 gallons per day)
<b>Alternative 7A2 - Partial Sediment Removal with Road or Rail Sediment Transport(Lower Reservoir, 4.2 million cubic yards) (4)</b>		
Volume of water generated from hydraulically dredged sediments (50% of sediments) (5)	2,406,670,984 gallons	(592 days* 4,065,323 gallons per day)
Volume of water generated from mechanically dredged sediments (50% of sediments) (5)	127,394,785 gallons	(841 days*151,480 gallons per day)
Volume of water generated per day	4,216,803 gallons/day	(4,065,323 gallons per day hydraulic + 151.480 gallons per day
Total volume of water generated	2,534,065,769 gallons	
<b>Slurry Transport Option</b>		
Total volume of water generated with hydraulic dredge of 100% of sediments (5)	4,813,341,968 gallons	(592 days*2* 4,065,323 gallons per day)

**Notes:**

1. Estimated hydraulic dredge production rates are based on the USACE September 20, 2000 Evaluation of Dredging Costs (Appendix I1) Based on a 12 inch cutter - suction dredge with a dredging rate of 296 cubic yards/hour. Dredge operation assumes 24 hour/day operation with 50 percent efficiency (i.e., 12 operating hours/day). However, due to weather, debris, equipment failure and other factors, this efficiency may not be achieved.
2. Water generated per day is calculated based on assuming 100% dewatering of removed material. Therefore, this number represents a conservative value for estimating water handling and treatment volumes.
3. The 2,500 cubic yards per day estimated conventional equipment production rate is based on AERL's experience during the Lower Area One removal (which averaged 2,200 cubic yards per day).
4. Removal volumes are from Table 4-6 and include continued input and deposition of sediments from upstream during construction which would increase the volumes of material.
5. Hydraulic dredge and conventional equipment excavation timeframes are from Table 4-7. For total removal, conventional equipment excavation accounts for 50% and hydraulic dredging excavation for 50% of sediment removal except for the slurry transport option where 100% of sediments are removed using hydraulic dredging.

Table 5-1  
Remedial Alternatives Detailed Analysis Evaluation Matrix  
Milltown Reservoir Combined Feasibility Study

Alternatives		Performance Evaluation of Remedial Alternatives Against Detailed Analysis Subcriteria (1)																											
		Overall Protection of Human Health and the Environment	Compliance with ARARs						Long-Term Effectiveness and Permanence					Reduction of Toxicity, Mobility, and Volume Through Treatment	Short-Term Effectiveness						Implementability								Capital / Operating and Maintenance Cost (2)
			Contaminant Specific			Location specific		Action Specific	Magnitude of Residual Risk				Adequacy and Reliability of Controls		Protection of Community and Workers During Remedial Actions	Environmental Impacts of Implementation			Time Until RAOs are Achieved	Technical Feasibility				Administrative Feasibility	Availability of Services and Facilities				
			WQB-7 Surface Water Criteria		WQB-7 Groundwater Criteria	Floodplain Regulations	Protected Resources	Solid Waste	Surface Water and Aquatic System	Groundwater	Vegetation and Terrestrial Ecosystem	Catastrophic Release Potential				Wetlands/ Terrestrial	Turbidity/ Water Quality	Geomorphic Stability		Ability to Construct and Operate the Technology	Reliability of Technology	Ability to Monitor Effectiveness	Ease of Undertaking Additional Actions	Ability to Obtain Approvals/Coordination with Other Agencies	Availability of Necessary Equipment, Specialists, Materials	Availability of Off-site Facilities			
			Typical	High Flow & Ice Scour																									
1	No Further Action	Not Protective	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR		
2A	Modification of Dam and Operational Practices plus GW ICs	mod-high	moderate	moderate	low-mod	mod-high	high	mod-high	moderate	moderate	mod-high	moderate	moderate	low-mod	high	high	high	high	moderate	high	mod-high	high	mod-high	high	high	high	high		
2B	Modification of Dam and Operational Practices plus GW ICs and Containment and Natural Attenuation within Aquifer Plume	moderate	moderate	moderate	moderate	mod-high	high	mod-high	moderate	mod-high	mod-high	moderate	moderate	moderate	high	high	mod-high	high	moderate	moderate	moderate	high	mod-high	high	mod-high	mod-high	mod-high		
3A	Modification of Dam and Operational Practices with Scour Protection plus GW ICs	mod-high	moderate	moderate	low-mod	mod-high	high	mod-high	moderate	moderate	mod-high	moderate	moderate	low-mod	high	high	high	high	moderate	high	moderate	high	mod-high	high	high	high	mod-high		
3B	Modification of Dam and Operational Practices with Channelization plus GW ICs and Containment and Natural Attenuation within Aquifer Plume	moderate	moderate	moderate	moderate	mod-high	mod-high	mod-high	moderate	mod-high	mod-high	mod-high	moderate	moderate	mod-high	mod-high	moderate	mod-high	moderate	moderate	moderate	high	mod-high	mod-high	mod-high	moderate	moderate		
5	Dam Removal, Partial Sediment Removal with Channelization and Leachate Collection/Treatment, plus GW ICs and Natural Attenuation within Aquifer Plume	moderate	moderate	moderate	moderate	mod-high	low-mod	mod-high	low-mod	mod-high	low	high	low	moderate	mod-high	mod-high	moderate	moderate	moderate	moderate	moderate	moderate	high	moderate	low-mod	moderate	moderate	low-mod	
6A	Modification of Dam and Operational Practices with Initial Total Sediment Removal of the Lower Reservoir Area and Periodic Sediment Removal Thereafter, plus GW ICs and Natural Attenuation within Aquifer Plume	moderate	mod-high	mod-high	high	moderate	moderate	mod-high	mod-high	high	moderate	mod-high	moderate	mod-high	low-mod	moderate	low-mod	moderate	moderate	moderate	moderate	moderate	high	moderate	moderate	moderate	moderate	low-mod	
6B	Modification of Dam and Operational Practices with Total Sediment Removal of the Entire Reservoir and Periodic Sediment Removal Thereafter, plus GW ICs and Natural Attenuation within Aquifer Plume	moderate	mod-high	mod-high	high	low-mod <sup>(3)</sup>	low-mod	mod-high	mod-high	high	moderate	mod-high	moderate	mod-high	low-mod	moderate	low-mod	low-mod	moderate	low-mod	low-mod	high	moderate	moderate	moderate	low-mod	low		
7A	Dam Removal with Total Sediment Removal of the Lower Reservoir Area plus GW ICs and Natural Attenuation within Aquifer Plume	mod-high	moderate	mod-high	high	moderate	mod-high	mod-high	high	high	mod-high	high	high	mod-high	low-mod	moderate	low-mod	moderate	moderate	moderate	moderate	high	low-mod	low-mod	moderate	moderate	low-mod		
7B	Dam Removal with Total Sediment Removal of the Entire Reservoir plus GW ICs and Natural Attenuation within Aquifer Plume	mod-high	moderate	mod-high	high	low-mod <sup>(3)</sup>	moderate	mod-high	high	high	mod-high	high	high	mod-high	low-mod	moderate	low-mod	low-mod	moderate	low-mod	low-mod	high	low-mod	low-mod	moderate	low-mod	low		

Notes:  
NR = Not Rated  
NA = Not Applicable  
1. Alternatives are evaluated based on relative achievement of the criterion compared to other alternatives using the following ranking system: low = low achievement; low-mod = low to moderate achievement; moderate = moderate achievement; mod-high = moderate to high achievement; and high = high achievement.  
2. Cost break points (based on alternative present value costs) are as follows: \$0-\$25M = high; \$26-\$60M = mod-high; \$61-\$100M = moderate; \$101-150M = low-mod; >\$150M = low. Where multiple sediment transport/disposal options exist for a removal alternative the lowest-cost option is used.  
3. Rated as "low-mod" due to the potential need to encroach on the floodplain with a "near reservoir" disposal facility sized to accept a "total removal" sediment volume.

**Table 5-2**  
**Summary of Detailed Analysis of Remedial Alternatives**  
**Milltown Reservoir Combined Feasibility Study**

Alternatives	Performance Evaluation of Remedial Alternatives Against Detailed Analysis Criteria (1)						
	Threshold Criteria		Balancing Criteria				
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume Through Treatment	Short-Term Effectiveness	Implementability	Capital / Operating and Maintenance Cost (2)
1 No Further Action	Not Protective	NR	NR	NR	NR	NR	NR
2A Modification of Dam and Operational Practices plus GW ICs	mod-high	moderate	moderate	low-mod	high	high	high
2B Modification of Dam and Operational Practices plus GW ICs and Containment and Natural Attenuation within Aquifer Plume	moderate	moderate	moderate	moderate	mod-high	moderate	mod-high
3A Modification of Dam and Operational Practices with Scour Protection plus GW ICs	mod-high	moderate	moderate	low-mod	high	mod-high	mod-high
3B Modification of Dam and Operational Practices with Channelization plus GW ICs and Containment and Natural Attenuation within Aquifer Plume	moderate	moderate	moderate	moderate	moderate	moderate	moderate
5 Dam Removal, Partial Sediment Removal with Channelization and Leachate Collection/Treatment, plus GW ICs and Natural Attenuation within Aquifer Plume	moderate	moderate	low-mod	moderate	moderate	moderate	low-mod
6A Modification of Dam and Operational Practices with Initial Total Sediment Removal of the Lower Reservoir Area and Periodic Sediment Removal Thereafter, plus GW ICs and Natural Attenuation within Aquifer Plume	moderate	mod-high	mod-high	mod-high	low-mod	moderate	low-mod
6B Modification of Dam and Operational Practices with Total Sediment Removal of the Entire Reservoir and Periodic Sediment Removal Thereafter, plus GW ICs and Natural Attenuation within Aquifer Plume	moderate	mod-high	mod-high	mod-high	low	moderate	low
7A Dam Removal with Total Sediment Removal of the Lower Reservoir Area plus GW ICs and Natural Attenuation within Aquifer Plume	mod-high	moderate	high	mod-high	low-mod	moderate	low-mod
7B Dam Removal with Total Sediment Removal of the Entire Reservoir plus GW ICs and Natural Attenuation within Aquifer Plume	mod-high	moderate	high	mod-high	low	low-mod	low

**Notes:**

NR = Not Rated

- Alternatives are evaluated based on relative achievement of the criterion compared to other alternatives using the following ranking system: low = low achievement; low-mod = low to moderate achievement; moderate = moderate achievement; mod-high = moderate to high achievement; and high = high achievement
- Cost break points (based on alternative present value costs) are as follows: \$0-\$25M = high; \$26-\$60M = mod-high; \$61-\$100M = moderate; \$101-150M = low-mod; >\$150M = low. Where multiple sediment transport/disposal options exist for a removal alternative the lowest-cost option is used.

**Table 5-3**  
**Remedial Alternatives Present Value (PV) and Total Cost Summary Table**  
**Milltown Reservoir Combined Feasibility Study**

Remedial Alternative	PV Capital Costs	PV O&M Costs	PV Site Monitoring Costs	PV Periodic Costs	Total Estimated PV Cost	Total Estimated Cost
<b>Alternative 1 (3)</b>	\$ 11,998,713	\$ 3,379,859	\$ 2,232,785	\$ 107,903	\$17,719,259	\$ 49,795,897
<b>Alternative 2A (3)</b>	\$ 13,891,487	\$ 3,899,285	\$ 2,232,785	\$ 248,516	\$20,272,073	\$ 60,547,983
<b>Alternative 2B (3)</b>	\$ 19,810,153	\$ 4,653,961	\$ 2,396,431	\$ 285,916	\$27,146,460	\$ 72,942,798
<b>Alternative 3A (3)</b>	\$ 21,951,508	\$ 5,378,252	\$ 2,232,785	\$ 411,870	\$29,974,415	\$ 78,696,478
<b>Alternative 3B (3)</b> (to Local Wet Repository w/Slurry Transport)	\$ 63,199,514	\$ 6,760,876	\$ 2,726,375	\$ 27,130,758	\$99,817,523	\$ 365,190,244
<b>Alternative 5</b> (to Local Wet Repository w/Slurry Transport)	\$ 58,629,053	\$ 46,964,409	\$ 2,562,729	\$ 377,653	\$108,533,844	\$ 425,043,546
<b>Alternative 6A (3)</b> (to Local Wet Repository w/Slurry Transport)	\$ 108,448,728	\$ 5,598,246	\$ 3,686,007	\$ 13,810,180	\$131,543,162	\$ 455,213,643
<b>Alternative 6B (3)</b> (to Local Wet Repository w/Slurry Transport)	\$ 180,247,619	\$ 8,389,764	\$ 4,305,643	\$ 10,184,941	\$203,127,966	\$ 634,893,803
<b>Alternative 7A1</b> (to Local Wet Repository w/Slurry Transport)	\$ 114,354,252	\$ 3,682,404	\$ 3,686,007	\$ 325,906	\$122,048,569	\$ 193,481,287
<b>Alternative 7A2</b> (to Local Wet Repository w/Slurry Transport)	\$ 85,838,831	\$ 3,459,977	\$ 3,532,066	\$ 348,565	\$93,179,439	\$ 167,838,112
<b>Alternative 7B</b> (to Local Wet Repository w/Slurry Transport)	\$ 193,413,583	\$ 6,948,819	\$ 4,305,643	\$ 485,342	\$205,153,387	\$ 384,597,688

Notes:

1. See Appendix I1 for detailed backup for Remedial Alternatives Costs.
2. Where multiple sediment transport/disposal options exist for a removal alternative, the lowest cost option is used.
3. The Total Estimated PV Costs and Total Estimated Costs for alternatives that maintain Milltown Dam include Non-Superfund (i.e.FERC-related) Costs of \$15,378,572 and \$35,687,097, respectively.

**Table 6-1**  
**Comparative Analysis of Alternatives for the Milltown Reservoir Combined Feasibility Study**

Alternatives	Comparative Analysis of Remedial Alternatives <sup>(1)</sup>							
	Threshold Criteria		Balancing Criteria					Overall Score
	Overall Protection of Human Health and the Environment	Compliance with ARARs	Long-Term Effectiveness and Permanence	Reduction of Toxicity, Mobility, and Volume Through Treatment	Short-Term Effectiveness	Implementability	Capital / Operating and Maintenance Cost	
1 No Further Action	Not Protective	NR	NR	NR	NR	NR	NR	NR
2A Modification of Dam and Operational Practices plus GW ICs	4	3	3	2	5	5	5	27
2B Modification of Dam and Operational Practices plus GW ICs and Containment and Natural Attenuation within Aquifer Plume	3	3	3	3	4	3	4	23
3A Modification of Dam and Operational Practices with Scour Protection plus GW ICs	4	3	3	2	5	4	4	25
3B Modification of Dam and Operational Practices with Channelization plus GW ICs and Containment and Natural Attenuation within Aquifer Plume	3	3	3	3	3	3	3	21
5 Dam Removal, Partial Sediment Removal with Channelization and Leachate Collection/Treatment, plus GW ICs and Natural Attenuation within Aquifer Plume	3	3	2	3	3	3	2	19
6A Modification of Dam and Operational Practices with Initial Total Sediment Removal of the Lower Reservoir Area and Periodic Sediment Removal Thereafter, plus GW ICs and Natural Attenuation within Aquifer Plume	3	4	4	4	2	3	2	22
6B Modification of Dam and Operational Practices with Total Sediment Removal of the Entire Reservoir and Periodic Sediment Removal Thereafter, plus GW ICs and Natural Attenuation within Aquifer Plume	3	4	4	4	2	3	1	21
7A Dam Removal with Total Sediment Removal of the Lower Reservoir Area plus GW ICs and Natural Attenuation within Aquifer Plume	4	3	5	4	2	3	2	23
7B Dam Removal with Total Sediment Removal of the Entire Reservoir plus GW ICs and Natural Attenuation within Aquifer Plume	4	3	5	4	2	2	1	21

Notes:

NR = Not Rated

1. Alternatives are numerically scored based on relative achievement of the criterion compared to other alternatives using the following ranking system: 1 = low achievement;

2 = low to moderate achievement; 3 = moderate achievement; 4 = moderate to high achievement and 5 = high achievement. See Tables 5-1 and 5-2 for achievement bases.